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Two Cohorts of Severely Injured Trauma Patients, Nearly Two Decades Apart: Unchanged Mortality But Improved Quality of Life Despite Higher Age

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Background: **The care for trauma patients has undergone major changes during the last decades. Additionally, many injury prevention measures have been established. The objective of these efforts was to reduce the number of traumatic incidents and to reduce mortality and morbidity in injured patients. The aim of our study was to assess how these measures and improved care have altered trauma mechanisms, occurrence of injuries, treatment, and outcome in the trauma population treated at our trauma center.**

Methods: **Two cohorts of trauma patients with an Injury Severity Score >15, treated at the University Medical Center Groningen were compared. The first cohort was treated from 1985 to 1990, the second cohort from September 2002 to January 2005.**

Results: **The annual mean number of severely injured patients increased by 76%. Fourteen percent more patients had sustained an injury at home. The mean age increased from 33 ± 22 years to 41 ± 23 years. The presence of severe head and neck injuries in the patients increased from 62% to 73%. Inhospital mortality remained unchanged at 25%. The outcome of survivors improved; 67% of patients made a moderate or good recovery versus 40% almost 20 years ago.**

Conclusions: **Striking are the consequences of the aging of the Dutch population: an almost 10-year increase in mean age and a rise in severe head and neck injuries in the population treated at our trauma center. The unchanged mortality and improved outcome of survivors represented the enhanced trauma care.**

Key Words: **Trauma, Multiple injuries, Injuries, Mortality, Glasgow Outcome Scale.**

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The care for trauma patients has undergone major changes during the last decades. Among these changes are the institution of Advanced Trauma Life Support, transport of patients by helicopter, and damage control surgery. In the Netherlands, the designation of Level I trauma centers and mobile medical teams in 1999 have upgraded trauma care. Not only has medical care undergone changes, numerous injury prevention measures have also been established during the last 20 years. Primary prevention measures include speed limits, improved right of way rules, banned use of a mobile phone by drivers, enhancement of infrastructure, campaigns to promote road safety and dissuade the use of alcohol, and stricter police control. Among secondary prevention measures were the institution of legislation to require motorcycle and moped helmets, seatbelts, and baby chairs for bicycles and motor vehicles, and the increased safety of vehicles.[1] Tertiary prevention measures included the institution of a national emergency phone number to reduce response times and the aforementioned upgraded trauma care. The objective of these medical and societal efforts was to prevent traumatic incidents and injuries, and in case of casualties to reduce mortality and morbidity. The nationwide reduction of traffic deaths from almost 11 per 100,000 inhabitants per year in the mid 1980s to less than 6 deaths per 100,000 inhabitants, despite a rise in mobility of almost 25 billion miles per year, in 2004 is clear.[2] Until now, it has not been known if all aforementioned goals have been achieved. For example, international literature describes a range from unchanged to improved outcomes after trauma center implementation.[3–6] However, we think that the Dutch trauma population, with its low proportion of penetrating injuries, differs from most published populations. The aim of our study was to assess in which way the sustained efforts have altered trauma mechanisms, occurrence of injuries, treatment, and outcome in two cohorts of severely injured trauma patients, almost two decades apart.

MATERIALS AND METHODS

Two cohorts of trauma patients treated at the University Medical Center Groningen, University of Groningen, a Level I trauma center, were analyzed. The first cohort was treated from January 1985 to January 1990 (60 months), the second cohort was treated from September 2002 to January 2005 (28 months). Data were extracted from the trauma center's

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trauma registry database, which contains all primary and secondary admitted trauma patients of all ages with an Injury Severity Score (ISS) >15 and positive signs of life on arrival to the trauma center. The inclusion of patients in the trauma registry and collection of data were performed by a small number of trauma attending physicians and based on strict guidelines. As a result, the quality of data was high, without a significant number of missing patients or data.

The collected patient data included gender, age, mechanism of injury, duration of prehospital phase and mode of transport, diagnosis, ISS, Maximum Abbreviated Injury Scale (MAIS), treatment, number of days on respirator, Intensive Care Unit (ICU) stay and total hospital stay, inhospital mortality, Glasgow Outcome Scale (GOS) score at discharge,[7] and discharge destination.

The ISS was based on the 1998 Abbreviated Injury Scale (AIS) scores for each body region.[8] An injury to a body region was considered severe in case of an assigned AIS score >2. The most severely injured body region was defined by the highest AIS score, the MAIS, and categorized as follows: head and neck, thorax, abdomen, extremities. In case a patient sustained multiple injuries with identical AIS scores, the MAIS body score was classified according to risk of death: head and neck > thorax > abdomen > extremities.[9] The GOS quantifies functional outcome ranging from death (GOS score 1) to mild or no disability (GOS score 5).

Statistical Analysis

Data were expressed as mean ± SD or as median in the case of a skewed distribution. Differences between groups were assessed with the Student *t* test or the Mann-Whitney *U* test. Associations were assessed with the χ^2 test, Fisher's exact test, or the binomial test. Differences were considered significant for a two-tailed *p* value <0.05. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL) version 12.0.1 for Windows.

RESULTS

Demographics

From 1985 to 1990 (the first cohort) 748 trauma patients with an ISS >15 were admitted to the hospital, an average of 150 patients per year (Table 1). From 2002 to 2005 (the second cohort), an average of 264 patients with an ISS >15 were admitted to the trauma center annually, leading to a total of 615 patients and a mean increase of 76%. The second cohort was significantly older than the first cohort with a mean age of 41 ± 23 years (median of 39 years) versus a mean age of 33 ± 22 years (median of 26 years). Figure 1 illustrates the changed distribution of age in the studied cohorts. The male to female ratios remained unchanged; approximately three quarters of the patients were male.

The trauma mechanisms have also changed (Table 1). In the second cohort, 57% of the patients sustained their injury in traffic, whereas in the first cohort, 76% of the patients were traffic casualties. The distribution of involved vehicles (car, truck, motorbike, moped, bicycle, pedestrian) did not change significantly. In the second cohort, more people were injured at home than were people in the first cohort: 23% versus 9%. The age in this subgroup of patients injured at home has dramatically increased from 33 ± 22 years to 52 ± 25 years. Similarly, those who were injured at work in the second cohort were also older; an increase in age from 25 ± 17 years to 45 ± 16 years.

Table 1 Demographic Data of Both Cohorts

	1985–1989	2002–2004	*p*
No. patients			
Total	748	615	
Mean/yr	150	264	
Gender (% male)	76	72	NS
Age (yr)*	33 ± 22 (26)	41 ± 23 (39)	<0.001
Type of accident (% of patients)			
Traffic	76	57	<0.001
Home	9	23	<0.001
Work	6	7	NS
Sport	3	7	<0.001
Other	5	6	NS
Unknown	1	—	—

* Mean ± SD (median).
NS, not significant; $p > 0.05$.

Prehospital Data

In the first cohort a mean of 45 ± 41 minutes elapsed between the trauma incident and arrival of patients directly referred to the trauma center. All patients were transported by ambulance. The prehospital phase of directly referred patients of the second cohort lasted longer ($p < 0.001$): 82 ± 58 minutes, even though 12% of the patients was transported by helicopter. Additionally, fewer patients were secondarily referred from a local hospital: 28% of the second cohort versus 35% of the first cohort ($p = 0.005$). Approximately all patients of both cohorts were referred from the local hospital to the trauma center within 24 hours after sustaining the injury.

Injuries

Proportionally, a strong reduction of injuries to all AIS body regions was noticeable in the second cohort; except for head and neck and facial injuries, for which occurrences have remained similar. The second cohort was slightly less severely injured according to the ISS than the first cohort was: a mean of 25 ± 10 versus a mean of 28 ± 21 ($p < 0.001$). In the second cohort, fewer AIS body regions were severely affected per patient than in the first cohort: 1.5 ± 0.7 (median 1) versus 1.9 ± 0.9 (median 2) ($p < 0.001$). This reduction accounted for all trauma mechanisms. Nevertheless, in cases of head and neck injuries, a severe injury was more often included (Fig. 2). Seventy-three percent of the patients in the second cohort suffered from severe head and neck injuries, in

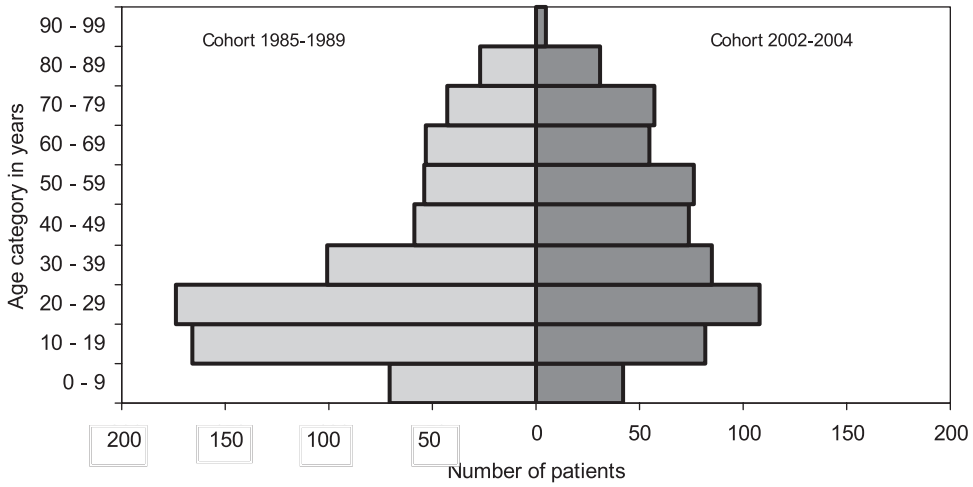

Fig. 1. *Distribution of age (in years) of both cohorts.*

contrast to 62% of the patients in the first cohort ($p < 0.001$). In absolute numbers of patients (mean/year), this rise is even more striking: 94 patients in the first cohort versus 189 patients in the second cohort. The occurrences of severe chest, abdominal, and extremities injuries showed significant reductions in percentages but in absolute numbers per year the occurrence of severe injuries to these AIS body regions have remained static. The number of patients with severe facial injuries or injuries to the "external" region was too small to be statistically relevant.

Clinical Course

Regarding treatment, patients were less often operated on in the second cohort: 45% of the patients underwent one or more surgical procedures versus 59% of the patients in the first cohort ($p < 0.001$). Sixty-two percent of the second cohort was admitted to the ICU, which is almost 10% less than in the first cohort (Table 2). The length of the ICU stay has remained stable at 9 days. A smaller percentage of the ICU patients was intubated and mechanically ventilated in the second cohort when compared with those in the first cohort: 79% versus 93%; however, the duration of intubation has increased from 7 to 9 days.

Mortality

The mortality rate was equal in both cohorts: 24% to 25% (Fig. 3). This accounted for all subgroups of mechanisms of trauma. The causes of death have not significantly

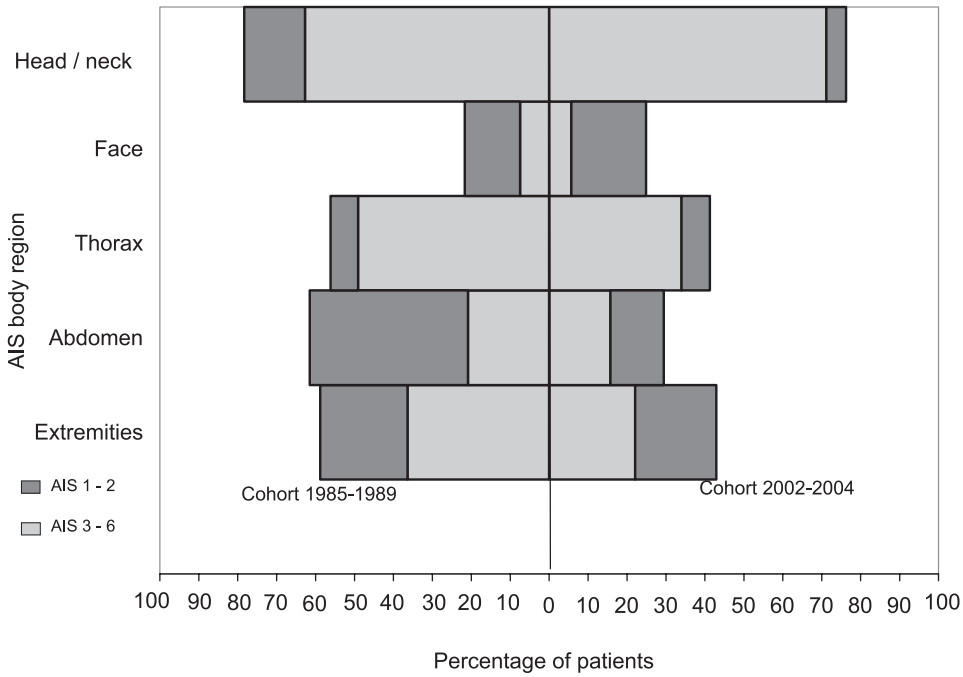

Fig. 2. *Distribution of total injuries and severe injuries per AIS body region in percentage of patients of both cohorts. AIS, Abbreviated Injury Score.*

Table 2 **Duration of Intubation, Length of Stay at the Intensive Care Unit, and Inhospital Stay**

	1985–1989	2002–2004	*p*
Intubation			
Patients (%)	77	57	<0.001
Duration*	7 ± 11 (3)	9 ± 13 (4)	<0.001
Intensive care admission			
Patients (%)	71	62	<0.001
Length of stay*	9 ± 13 (5)	9 ± 13 (4)	NS
Total hospital stay			
Length of stay*	24 ± 26 (17)	19 ± 21 (12)	0.007

* Days, mean ± SD (median).
NS, not significant; $p > 0.05$.

changed. Approximately 60% of deaths in both cohorts were caused by cerebral injury. Uncontrolled hemorrhage (approximately 12% in both cohorts) and respiratory failure (10% in both cohorts) were other leading causes of death. However, the time to death has increased ($p < 0.001$). The mean time between arrival to the trauma center and death of the second cohort was 4.2 ± 8.3 days, median 0.9 days, whereas it was 1.5 ± 8.4 days, median 0.2 days, in the first cohort. The age of the nonsurvivors increased from 38 ± 25 years in the first cohort to 47 ± 25 years in the second cohort ($p < 0.001$), but their ISS diminished from 42 ± 20 to 32 ± 12 ($p < 0.001$). Regarding mortality per MAIS, the only significant change occurred in the head and neck region: in the first cohort, 38% of these patients died, in contrast to 29% in the second cohort ($p < 0.001$). In other MAIS regions, the mortality remained stable at approximately 10% to 15%.

Outcome of the Survivors

In the second cohort the total hospital stay was shorter when compared with that of the first cohort: 24 ± 26 days versus 19 ± 21 days, respectively (Table 2). The outcome of survivors at discharge has significantly improved in the second cohort (Fig. 3). Although the percentage of patients in a vegetative state (GOS score 2) has remained stable at approximately 2%, the percentage of severely disabled patients (GOS score 3) has strongly diminished from 32% to 7% ($p < 0.001$). An increased percentage of patients, from 40% to 67%, made a good recovery (GOS scores of 4 and 5) ($p < 0.001$). This phenomenon accounted for all MAIS regions: a 20% to 30% rise in patients making a good recovery. For the MAIS head and neck region, this concerned an increase from 34% to 64% ($p < 0.001$). This was the result of a large reduction in severely disabled patients, from 24% in the first cohort to 6% in the second cohort. Furthermore, the incidence of GOS score 2 has remained stable at approximately 3%. Only slight shifts have occurred in discharge destination.

DISCUSSION

The data presented demonstrate that during the last 20 years many changes have occurred. Although road traffic incidents still are the leading cause of injury, more people sustained injuries at home. Besides the increased number of treated patients, the almost 10-year increase in the mean age of the second cohort is impressive. Also remarkable is the almost 10% increase in the incidence of severe head and neck injuries. In terms of morbidity, the outcome of survivors has dramatically improved because 67% made a moderate or good recovery. The proportion of nonsurvivors did not change during both study periods. Apparently, the improvements in trauma care during the last 20 years are not reflected by the *quantity* of lives saved but by the *quality* of lives saved.

Increased Patient Load

Striking is the 76% increase of severely injured patients admitted to the trauma center. Previous publications have described an increase in severely injured patients treated in a newly implemented trauma center.[4,5] However, the designation as a trauma center did not expand the catchment area of

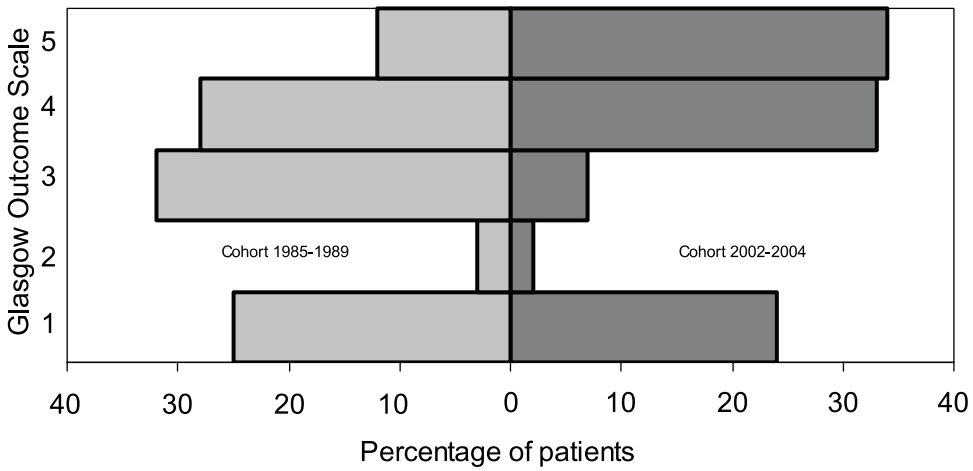

Fig. 3. *Distribution of Glasgow Outcome Scale scores in percentage of patients of both cohorts.*

the hospital. Furthermore, the number of inhabitants of the region has only increased by 7% from 1.6 million in the mid 1980s to 1.7 million in 2002.[2] Most likely, the increased number of patients is the result of the strict guidelines for triage and secondary referrals implemented with the nationwide designation of 10 trauma centers. Before the designation, triage was performed at random by the attending paramedics. Our results show an increased percentage of primary referred patients as the result of the more effective prehospital triage. A consequence of the catchment area that constitutes almost one quarter of the countries' area, is the rather long prehospital phase. Even though a significant number of patients were transported by helicopter, transport times are rather long. The prolonged prehospital phase is in agreement with the insights of delivery of high care to the trauma scene ("stay and play") instead of the "scoop and run" tactics in previous decades. A similar trend was seen in the United Kingdom.[6] The aforementioned improved prehospital care, combined with diminished response times after institution of a national emergency phone number may have reduced the number of people succumbing before reaching the hospital. Unfortunately, verification of this hypothesis is not possible because accurate data on prehospital deaths are not available.

Shift in Trauma Mechanisms and Injuries

In accordance with the countries' decreasing number of road traffic incidents, fewer severely injured traffic casualties were admitted to the trauma center. Preventive measures have reduced the number and severity of traffic incidents. However, a rising number of elderly people sustained severe injuries at home. Nationwide, almost three quarters of all trauma incidents happening at home involve people more than 70 years of age. In 75%, it concerns a fall that may or may not have been from height.[2] Striking is the increased incidence of severe head and neck injuries to 73% of all patients. This phenomenon is not limited to the Netherlands, as Kannus et al.[10] described similar results for Finland. Besides balance disturbances and less ability to anticipate to a fall, the preinjury widespread use of anticoagulants of elderly people may play an important role in causing intracranial bleedings.[11,12]

Lower ISSs were encountered in the second cohort. To conclude that the cohort was less severely injured would be premature. Inherent to the ISS formula, the smaller number of affected AIS body regions reduced the ISS. Our impression is that the change in trauma mechanisms diminished the number of injured body regions, but increased the severity of the sustained injuries: in other words, a shift from patients with *multiple* injuries to patients with *severe isolated* injuries.

Outcome

The unchanged mortality rate is disappointing at first sight. However, outcome after trauma is determined by time to definitive care, quality of care, injury severity, and host factors.[13] The current cohort greatly differed on these points from the 1985 to 1989 cohort. The time to definitive care was prolonged, but the quality of care is expected to have greatly improved. A statement on injury severity is difficult because the ISS was roughly unchanged, with a reduction of the number of body regions affected and altered distribution of severe injuries. Most important is the aforementioned increase in severe head and neck injuries, which are known for their poor outcome.[14] Host factors include gender, age, and preinjury medical state. Gender was unaffected, contrary to an increase in age of almost 10 years. This large increase in age is expected to have entailed extensive comorbidity. Analysis by Milzman et al.[15] showed an increased mortality rate based on preexisting conditions that were independent of age and ISS. Additionally, it has been well documented that, even in the absence of comorbidity, the risk of adverse outcomes increases with age, independent of other variables.[16,17]

With improved medical care on the one hand and the changed injury patterns plus worsened host factors on the other, the mortality rate was unaffected. However, the prolonged time to death may be indicative of enhanced prehospital and inhospital trauma care. With all improvements in care it appears that we were able to keep the patient alive during the most life-threatening phase, but unfortunately we did not save more lives in total.

We conclude that large advances have been made in trauma care, but the aging of patients and increased incidence of severe head and neck injuries has annulled the life-saving effect. Having dealt with major issues in the 20th century, in the current century a new hurdle in trauma care needs to be cleared: the management of an extending geriatric population that is severely injured after only a minor traumatic incident. Future preventive and protective measures should focus on elderly patients at home and altered care strategies should be considered.

Our study has several limitations, mostly because of its retrospection. Patients were identified from a trauma registry, fortunately without a significant amount of missing data. Unfortunately, only data concerning the trauma center have been analyzed, no data were available on casualties who were not treated in our facility. Another shortcoming is that some relevant items (e.g. complications and level of prehospital care) could not be analyzed because it was not scored in the first cohort. Analysis of outcome of survivors by means of the GOS is not preferable in patients without a traumatic brain injury. However, in this study, this concerned only a small minority of patients and other validated outcome scores (for example the sickness impact profile) have not been scored in the first cohort. For the same reason the successor of the GOS, the extended GOS, was not suitable either. A study to assess outcome in detail 1 year after the injury is in progress. Nonetheless, our data disclose valuable insights regarding severely injured trauma patients.

CONCLUSION

During the last 20 years many changes have occurred. The rise in severe head and neck injuries, the unchanged mortality, and the almost 10-year increase in mean age, are

inextricably bound with one another. The outcome of survivors has dramatically improved because 27% more patients made a moderate or good recovery. The improvements in trauma care are not reflected by the quantity of lives saved but by the quality of lives saved.

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